THE DIET OF THE BROWN WRASSE *LABRUS MERULA* (LABRIDAE) IN THE EASTERN ADRIATIC

by

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ABSTRACT. - The diet of the brown wrasse (*Labrus merula*) was investigated in studying the gut contents of 101 individuals sampled between April and July in Vrhovnjaci Archipelago and 93 individuals sampled between April and June at Island Palagruža, eastern middle Adriatic, Croatian waters. Decapods and bivalves were the major prey categories in both areas. Algae and gastropods were also frequently eaten but in much smaller amounts. The volume of the major food categories did not vary significantly with fish length. Fish longer than 20 cm did consume greater volumes of bivalves than smaller fish. The diet of both sexes was very similar in Vrhovnjaci ($C\lambda = 0.90$), while in Palagruža niche overlap between sexes was lower ($C\lambda = 0.63$).

RÉSUMÉ. - Le régime alimentaire de *Labrus merula* (Labridae) dans l'Adriatique orientale.

Pour étudier le régime alimentaire de *Labrus merula*, le contenu stomacal a été analysé chez 101 individus capturés entre avril et juillet dans l'archipel des Vrhovnjaci et chez 93 individus capturés entre avril et juin à l'île Palagruža, dans les eaux croates de l'Adriatique centrale orientale. Les décapodes et les bivalves sont les principales catégories de proies dans les deux zones. Les algues et les gastéropodes sont aussi fréquemment ingérés, mais dans une moindre mesure. Le volume des catégories principales ne varie pas significativement avec la longueur des individus bien que les individus au-delà de 20 cm de longueur consomment un plus grand volume de bivalves que les petits. Le régime alimentaire pour les deux sexes se ressemble plus à Vrhovnjaci ($C\lambda = 0,90$) qu'à Palagruža ($C\lambda = 0,63$).

Key-words. - Labridae, *Labrus merula*, MED, Eastern central Adriatic, Diet.

The brown wrasse, *Labrus merula* (L., 1758), is a common fish occurring in the Mediterranean, except the Black Sea, and in the eastern Atlantic from Portugal to Morocco including Azores (Quignard and Pras, 1986). It is usually found around rocks and seaweed in coastal areas at depths down to 50 m (Jardas, 1996).

Despite its high commercial value, very little is known about its feeding ecology. The brown wrasse is categorized as an obligatory carnivorous feeder preying on sea-urchins, ophiuroids, molluscs, crabs and worms (Quignard and Pras, 1986; Jardas, 1996). However, little is known on how the diet of the brown wrasse is affected by factors such as fish size, sex, location and season. Quignard (1966) presented a list of prey of the brown wrasse for French Mediterranean coastal waters. He pointed out that sea-urchins, ophiuroids, and molluscs are the main food of the brown wrasse. There are only a few brief studies describing the brown wrasse diet in the Adriatic Sea which point out that sea-urchins, molluscs and crustaceans are its main prey (Onofri, 1970, 1975).

This paper presents the first data about feeding preferences of the brown wrasse in relation to locality, month, size and sex in the eastern central Adriatic.

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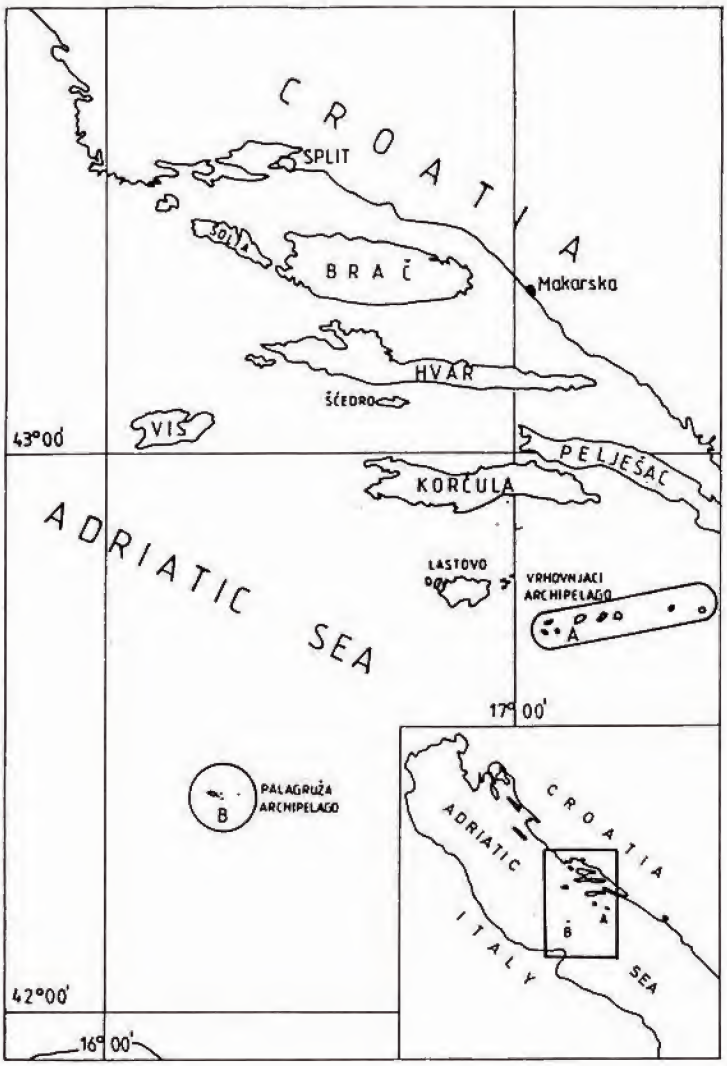

Fig. 1. - Locations of study area and sampling sites (**A**: Vrhovnjaci Archipelago; **B**: Palagruža) in eastern central Adriatic.

MATERIAL AND METHODS

Brown wrasses were sampled in Vrhovnjaci Archipelago and the island Palagruža (Fig. 1). A total number of 101 fish were captured from April to July in 1995 and 1996 in the Vrhovnjaci Archipelago (April: 4 females, mean TL 24.1 ± 0.5 cm, range 23.6-24.3 cm; May: 6 males, 50 females, mean TL 27.9 ± 2.1 cm, range 16.6-37.8 cm; June: 4 males, 17 females, mean TL 24.4 ± 0.9 cm, range 14.9-38.2 cm; July: 8 males, 2 females, mean TL 33.3 ± 1.8 cm, range 27.7-45.0 cm). At the island Palagruža, 93 brown wrasses were sampled be-

tween April and June 1996 (April: 6 males, 58 females, mean TL 27.5 ± 0.7 cm, range 21.1-39.8 cm; May: 20 females, mean TL 25.7 ± 0.9 cm, range 20.2-34.8 cm; June: 9 females, mean TL 21.5 ± 2.2 cm, range 11.0-28.9 cm).

Brown wrasses were captured by trammel nets in sheltered rocky areas, close to the shore, in depths between 5 and 15 m. The trammel nets were laid overnight, and fishes removed the following morning. They may have been in the nets up to a maximum period of 12 h. All fish were killed immediately on capture or on retrieval from the trammel nets, placed in separate plastic bags and stored frozen at -20°C within 1 h of capture.

After defrosting, total length (TL) and weight were measured to the nearest 1 mm and 0.01 g, respectively. Their age was determined by the technique described by Onofri (1975). The gut was weighed (wet weight) and its content identified. In the laboratory, prey items were identified to the lowest possible taxonomic level. The percentage frequency of occurrence and the percentage points (volume percentage) of each prey category consumed were calculated using the methods described by Hynes (1950).

Table I. - Relative proportions of food categories consumed by *Labrus merula* in Vrhovnjaci and Palagruža, determined by the percentage points (%Pts), and percentage occurrence (%Occ) methods.

	Vrhovnjaci		Palagruza	
	%Pts	%Occ	%Pts	%Occ
Algae	7.7	67.7	7.0	72.1
Foraminifera	0.1	6.3	-	-
Porifera	0.3	12.5	-	-
Hydrozoa	0.3	2.1	0.2	11.9
Gastropoda	7.2	72.9	8.9	74.0
Chitonida	0.2	7.3	0.2	7.5
Bivalvia	26.9	72.9	37.5	79.7
Polychaeta	3.2	58.1	2.8	59.1
Pycnogonida	0.1	1.0	0.1	1.3
Ostracoda	0.1	4.2	0.1	2.9
Copepoda	0.1	1.1	0.1	1.4
Cirripedia	1.8	31.2	0.4	17.6
Decapoda	17.2	72.0	27.4	72.8
Isopoda	0.5	10.8	3.5	18.7
Amphipoda	4.1	47.2	1.9	33.5
Insecta	0.1	6.5	0.1	5.5
Bryozoa	3.6	36.6	5.3	37.4
Echinodermata	1.6	22.9	2.1	28.8
Ascidiacea	1.1	8.3	5.5	23.8
Fish eggs	0.1	2.2	0.3	2.7
Fish remains	3.1	9.7	2.5	9.8
Grit	1.3	33.3	1.8	38.5
Digested	8.1	50.5	5.9	32.4
Unidentified	2.5	27.1	1.7	21.5
No. of fish examined	101		93	
No. of non-empty guts	98		91	

Dietary diversity or niche breadth was calculated using the Shannon-Weaver diversity index, H (Shannon, 1949): $H' = -\Sigma p_i \ln p_i$, where p_i is the proportion of the diet composed of a particular prey category, for n prey categories.

Dietary similarity or overlap between groups of fish was calculated using the overlap index $C\lambda$ of Zaret and Rand (1971): $C\lambda = 2\Sigma (px_i\ py_i) / \Sigma p2x_i + \Sigma p2y_i$, where n = number of food categories, px_i = proportion of food i in the diet of group x_i and py_i = proportion of food i in diet of group y. The similarity coefficient, $C\lambda$ varies from 0, where the samples are completely distinct without any overlap, to 1, where the samples are identical with total overlap. A value of 0.60 or more indicates a significant degree of similarity (Zaret and Rand, 1971).

RESULTS

Composition of diet

The diet of the Vrhovnjaci archipelago fish which included 20 different prey categories, was dominated by almost equal quantities of decapods and bivalves (Table I). Algae and gastropods occurred in much lower quantities though all four categories presented similar frequencies. The principal decapod species found were *Carcinus maenas*, *Galathea squamifera*, *Eupagurus anahoretus*, and *Scyllarus arctus*. *Arca noae* and *A. barbata* were the main bivalve species recorded, forming 80% of the total bivalve prey. *Cymodocea nodosa*, *Posidonia oceanica*, *Zostera marina* and *Fucus* spp. were the main components of the algal category. The most frequent gastropods, were *Littorina* spp., *Gibbula adriatica*, *Monodonta turbinata*, and *Bittium reticulatum*. *Paracentrotus lividus* and *Sphaerechinus granularis* were the commonest echinodermata preyed.

Bivalves also dominated the diet of the Palagruža fish (Table I). *Chlamys opercularis* was the principal species identified, forming about 70% of the total bivalve food though *Mytilus galloprovincialis* was also frequently recorded. Both bivalves and deca-pods (mainly *Maia squinado* and *Carcinus maenas*) occurred in similar frequencies as in Vrhovnjaci fish, though proportionally more bivalves and decapods prey were taken by the Palagruža populations. However this was not a significant difference in the diet between the two samples (Mann-Whitney U test; $p > 0.05$) and other categories such as gastropods (mainly *Patella coerulea* and *Bittium reticulatum*) and algae (*Posidonia oceanica* and *Laminaria* spp.) had approximately the same percentage volume as in the Vrhovnjaci fish. Significantly more cirripedia and amphipods were consumed by the Vrhovnjaci fish and more ascidians by the Palagruža brown wrasse ($p < 0.05$). Cirripedia, amphipods and ascidians were the only categories to differ significantly in percentage frequency of occurrence between the two populations (χ^2 test; $p < 0.05$).

As a consequence of the close similarity in dietary compostion, both populations had similar values of dietary breadth ($H' = 2.09$ and $H' = 2.02$ in Vrhovnjaci and Palagruža, respectively) and the degree of overlap between the samples was very high ($C\lambda = 0.89$).

Diet and fish size

In Vrhovnjaci Archipelago, bivalves and decapods where the main food items consumed by the brown wrasse in terms of volume by each size group (Table II). The consumption of most prey categories did not vary significantly with fish length (Spearman rank correlation coefficient, $p > 0.05$). Hydrozoans, polychaetes and echinoderms showed significant correlations with fish length ($r = -0.212$, $p < 0.01$; $r = -0.185$, $p < 0.05$; $r = 0.168$, $p < 0.05$).

The diet of the Palagruža wrasses did not show any clear length-related variation also (Table II). Bivalves and decapods were also the main components of the diet in each length

group. Ascidian and barnacle consumption was positively correlated with increasing length ($r = 0.310$, $p < 0.05$; $r = 0.250$, $p < 0.05$).

Corresponding to the absence of a clear length-related variation in dietary preferences by both populations, there was a little variation in dietary breadth with increasing fish size

Table II. - Volume percentages of food categories consumed by *Labrus merula* in each 5-cm length group in Vrhovnjaci and Palagruža

	Vrhovnjaci						Palagruza				
	Length group (cm)						Length group (cm)				
	15.5-19.9	20.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	10.0-14.9	20.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9
Algae	5.3	7.6	9.4	9.5	7.2	2.8	1.5	7.3	8.7	7.2	5.3
Foraminifera	0.2	-	0.2	0.2	0.3	-	-	-	-	-	-
Porifera	-	0.2	0.5	-	-	-	-	0.1	-	-	-
Hydrozoa	0.8	0.4	0.3	-	-	-	-	0.4	0.5	0.1	-
Gastropoda	5.1	7.2	8.5	10.3	5.1	0.6	-	9.2	8.8	4.8	18.2
Chitonida	0.1	0.2	0.2	-	-	-	-	0.4	-	0.3	-
Bivalvia	14.2	36.1	21.2	23.5	32.3	88.6	-	40.1	35.5	28.1	30.1
Polychaeta	4.9	2.8	2.6	2.7	1.3	-	-	3.3	2.6	4.6	1.7
Pycnogonida	0.3	-	-	-	-	-	-	0.2	-	-	-
Ostracoda	0.2	0.3	-	-	-	-	-	-	-	-	-
Copepoda	-	-	-	-	-	-	2.9	-	-	-	-
Cirripedia	0.1	0.4	0.3	0.1	0.8	0.7	0.5	2.3	0.8	2.1	1.1
Decapoda	39.0	25.7	20.8	24.2	35.8	-	67.8	15.1	17.7	18.1	4.6
Isopoda	4.3	0.2	4.4	5.1	5.6	-	3.8	0.6	0.2	0.5	-
Amphipoda	8.7	3.4	4.6	2.6	1.3	-	7.7	1.2	1.5	1.1	1.2
Insecta	-	0.1	0.1	-	-	-	-	0.1	0.2	0.1	-
Bryozoa	4.6	3.7	9.6	5.3	0.6	-	-	3.8	4.6	2.6	-
Echinodermata	-	2.1	2.0	2.7	0.2	-	-	-	-	-	-
Ascidiacea	0.5	-	2.2	1.8	-	-	-	4.1	5.2	9.8	29.1
Fish eggs	-	-	-	-	-	-	-	0.1	-	-	-
Fish remains	1.3	1.3	1.6	4.2	-	-	-	1.9	2.2	7.3	6.9
Grit	2.9	1.4	1.1	1.5	0.7	-	-	1.2	1.5	1.5	-
Digested	2.3	4.7	7.5	6.0	8.1	6.9	6.4	6.6	7.9	12.5	1.7
Unidentified	5.8	1.9	3.4	0.3	0.5	-	9.2	1.8	1.7	0.7	-

Table III. - Dietary diversity (H') of *Labrus merula* from Vrhovnjaci Archipelago and Island Palagruža.

Length group (cm)	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9	40-44.9
Vrhovnjaci	-	1.40	1.43	1.45	1.39	1.28	0.31
Palagruza	1.09	-	1.74	1.83	1.91	1.71	-

Month	April	May	June	July
Vrhovnjaci	1.29	2.1	1.97	1.62
Palagruza	1.88	1.48	1.81	-

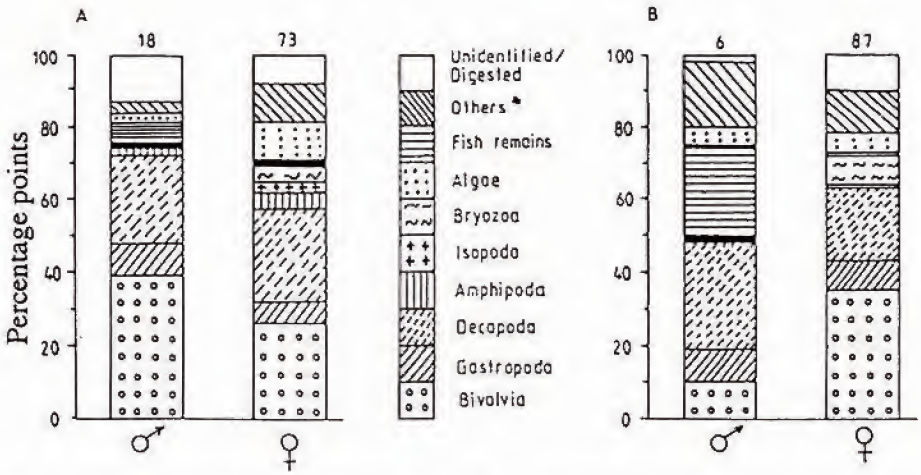

Fig. 2. - Percentage volume of food items consumed by male and female *Labrus merula* in Vrhovnjaci Archipelago and Palagruža: the combined percentage points of Foraminifera, Porifera, Hydrozoa, Chitonida, Polychaeta, Ostracoda, Copepoda, Cirripedia, Insecta, Pycnogonida, Echinodermata, Ascidiacea, fish eggs and grit. Numbers on top of histogram indicate the number of fish examined.

(Table III), though the number of items consumed per fish declined significantly with increasing fish length in Vrhovnjaci Archipelago.

Diet and sex

The percentage points composition of food items consumed by males and females is presented on figure 2. Both sexes presented similar size ranges, 20.5-45.0 cm in Vrhovnjaci archipelago and 28.0-39.3 cm in Palagruža, respectively. In Vrhovnjaci, the overall diet of males and females was similar, as illustrated by the high degree of dietary overlap between sexes ($C\lambda = 0.90$). Nevertheless, males consumed more bivalves and fish than females. However, females had a more diverse diet than the males ($H' = 2.08$ and 1.74, respectively) and took more algae, amphipods, isopods and bryozoans ($U = 335$, $p < 0.05$).

The degree of dietary overlap between sexes in Palagruža was lower than in the Vrhovnjaci population ($C\lambda = 0.63$) and the percentage points composition of their diet different. Palagruža males, which were all captured in April, consumed considerably fewer bivalves and more decapods and fish materials than the females. Despite these differences, the dietary diversity of the males was similar to that found for females ($H' = 1.79$ and $H' = 1.85$, respectively).

The diets of male brown wrasse from Vrhovnjaci and Palagruža differed significantly due to the greater consumption of algae, ascidians and fish and the lower intake of bivalves by the Palagruža brown wrasses compared with the Vrhovnjaci population ($p < 0.05$). Significantly more decapods and amphipods were taken by the females in Vrhovnjaci and more ascidians and bivalves by the Palagruža females ($p < 0.05$).

DISCUSSION

The results of this study have confirmed earlier observations which described the diet of the brown wrasse, *Labrus merula*, as principally composed of molluscs and crustaceans (Quignard, 1966; Onofri, 1970). Onofri (1970) presented only a list of prey items found in the brown wrasse in the eastern Adriatic (Pelješac channel), bivalves: *Arca barbata*, *A. noae*, *Lima inflata* and *Conus mediterraneus*; gastropoda: *Gibbula adriatica*, *Nassa cornicula* and *Calliostoma conulus*; decapoda: *Galathea squamifera*, *Eupagurus anahoretus*, *Carcinus maenas* and *Portunus arcuatus*; echinodermata: *Paracentrotus lividus* and *Sphaerechinus granularis*. Quignard (1966) presented a list of prey items of the brown wrasse in French Mediterranean coastal waters with their indexes of frequencies: I.F. = 0.50: *Paracentrotus lividus*, *Sphaerechinus granularis*, *Psammechinus microtuberculatus*; I.F. = 0.40: *Ophiura* sp., *Ophiotrix* sp., *Amphiura* sp.; I.F. = 0.25: *Cardium* sp., *Venus gallina*, *Modiola barbata*, *Modiolaria marmorata*, *Tellina* sp., *Chlamys* sp., *Arca* sp., *Lima* sp.; I.F. = 0.20: *Calliostoma* sp., *Nassa mutabilis*, *Haliotis lamellosa*; I.F. = 0.09: *Xantho* sp., *Carcinus maenas*, *Portunus* sp., *Macropodia* sp.; I.F. = 0.07: *Galathea strigosa*; I.F. = 0.05: *Pagures* sp.; I.F. = 0.03: *Porcellana longicornis*, *Porcellana platycheles*; I.F. = 0.02: Mysidacea; I.F. = 0.02: *Balanus* sp.; I.F. = 0.02: *Aphrodita* sp.; I.F. = 0.02: Serpulidae; I.F. = 0.01: Ostracoda: *Cypridina mediterranea*; I.F. = 0.01: *Chiton* sp. Bivalves and decapods combined represented > 50% of the diet and occurred in > 70% of the fish examined in Vrhovnjaci Archipelago and Island Palagruža. The preference of the brown wrasse for hard-bodied prey is evident, not only from the gut contents, but also from the structure of the mouth and gut. The constraint imposed on prey selection by the morphological characteristics of the predator have been noted previously for stickleback (Delbeek and Williams, 1988). The extensible jaws, forwardly projecting teeth and pharyngeal plates of the brown wrasse are well suited for preying on hard-shelled organisms (Onofri, 1970, 1975). Larsson (1975) reported that the ballan wrasse *Labrus bergylta* produced an audible crushing sound when crushing the shells of prey items in their pharyngeal teeth. These features, together with the relatively short, straight, thick walled gut (Onofri, 1970, 1975), indicate the carnivorous nature of the diet of *L. merula* and its ability to specialize on hard-bodied crustaceans and molluscs. Gerking (1994) reported that most wrasse species are crusher feeders. Regarding the analysis of diet variations with size, the numeric indices were not used since stomach contents were crushed and impossible to identify as individual prey items. Counting hard items resistant to digestion as whole organisms can lead to overestimating the importance of some food categories (Hyslop, 1980).

The brown wrasse foraged mainly during the day (Onofri, 1970, 1975), and while some feeding activity occurred at dusk, no foraging was observed at dawn. As the trammel nets used in this study were laid overnight and the brown wrasse removed the following morning, it is possible that part of the food could have been digested. In both Vrhovnjaci and Palagruža, only 6% and 8% of the food, respectively, were classified as digested material. In this case, with the presence of undigested molluscan and crustacean shells, it is possible for an overestimation of the percentage volume occupied by such hard-bodied prey and for an underestimation of the amount of soft-bodied prey such as polychaetes and insects.

Despite some differences observed in percentage points composition of the principal dietary components of fish in both areas, the high niche overlap between the two populations indicated the close similarity in their feeding strategies. As opportunism within defined food niches is commonly recorded in fish (Werner and Hall, 1976), these differences may indicate the relative local availability of the prey. The volume of main components of the diet did not vary significantly with fish length in either population. All the brown wrasses studied were

larger than 14 cm in length, and therefore greater length-related variations in diet may have been observed if younger and smaller fish have been available in the samples.

The apparent high selection for bivalves by the 40-44.9 cm length group in the Vrhovnjaci reflects the diet of just three specimens. The diet of the Palagruža brown wrasse also did not show a clear length-related variation. As only two fish were examined in the smallest size class, the increased consumption of gastropods by the largest brown wrasses may not accurately represent the true dietary trend.

The period from March to April (included) corresponds to the spawning season of the brown wrasse (Grubišić, 1982; Jardas, 1996). During this time, male brown wrasses, which are territorial, defend an area in which spawning takes place and the eggs are laid (Šoljan, 1968). These activities may limit the time available for foraging and affect their dietary preferences. Šoljan (1968) noted that territorial fish exhibited wider food niches during the spawning period, a result of having to eat a wider variety of food organisms within a restricted area.

The diet of both sexes was very similar in Vrhovnjaci Archipelago, while in Palagruža niche overlap between sexes was much lower. At both locations, males consumed considerably more fish, while females feed on greater proportions of algae and bryozoans. The greater consumption of algae by the female brown wrasse may be possibly a result of the fact that females clear algae from rock surfaces during the spawning season (Šoljan, 1968).

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